WHAT IS CLAIMED IS:

1. A method of applying a surface treatment to a surface of a substrate, the surface treatment being selected from a group consisting of the following surface treatments: coating, denaturation, modification and etching, said method comprising the steps of:

bringing a surface treatment gas into contact with a surface of a substrate; and

irradiating the surface of the substrate with a fast particle beam to enhance an activity of the surface and/or the surface treatment gas thereby facilitating the reaction between the surface and the gas.

2. A method as set forth in claim 1, in which said fast particle beam is selected from a group consisting of an electron beam, a charged particle beam, an atomic beam and molecular beam.

3. A method as set forth in claim 2, in which said surface treatment is coating of the surface of the substrate, said method comprising the steps of:

chemically depositing predetermined component elements of the gas onto the surface of the substrate, and

irradiating a predetermined portion in the surface of the substrate prior to, simultaneously with, and/or following said step of bringing the surface treatment gas into contact with the surface.

4. A method as set forth in claim 3, in which the substrate is a silicon substrate for fabricating a semiconductor device, the substrate being provided on its surface with an interconnect pattern recess, and the surface treatment gas is an organic complex gas containing copper as a component element thereof which is to be deposited onto the surface of the substrate.

5. A method as set forth in claim 4, in which said irradiation step is carried out with the fast particle beam having particle energy in the range of 200 eV - 10 keV.

6. A method as set forth in claim 1, in which said surface treatment is coating of the surface and said substrate has an interlayer insulative film layer as a top

layer, said method comprising the steps of:

forming a diffusion barrier layer in contact with the interlayer insulative film layer by depositing predetermined component elements of the gas onto the surface of the interlayer insulative film layer; and

irradiating the diffusion barrier layer with a fast particle beam to form a strongly combined layer formed by the mixed atoms or molecules between the insulative layer and the diffusion barrier layer.

7. A method as set forth in claim 6, in which the interlayer insulative film layer is formed from a material consisting essentially of an organic material of low dielectric constant and the diffusion barrier layer is formed from a metal or a compound.

8. A method as set forth in claim 6, in which the surface of the substrate to be subjected to the coating defines an interconnect or circuit wiring pattern recess, and said diffusion barrier layer is formed over the surface of the recess to define a recess corresponding to the interconnect pattern recess, said method further including a step of filling the recess defined by the diffusion barrier layer to form an interconnect of a semiconductor device.

9. A method as set forth in claim 8, in which said irradiation step is carried out with the fast particle beam having particle energy in the range of 800 eV - 2 MeV.

10. A method as set forth in claim 1, in which said surface of the substrate is provided with a recess and said surface treatment is coating of the surface, said method further comprising the steps of:

changing the angle at which the particle beam impinges on the surface of the substrate while irradiating the surface of the substrate with the fast particle beam so that the entire surface of the substrate including a surface portion defining the recess is irradiated with the fast particle beam.

11. A method as set forth in claim 10, in which said fast particle beam is a collimated beam.

12. A method as set forth in claim 10, in which the coating is conducted in such a manner that the aspect ratio B/A of the recess defined by the coating layer formed on the surface of the recess is kept constant or gradually decreases until the coating layer grows to fill the recess of the surface of the substrate, wherein B is a depth of the recess and A is a width of the mouth of the same.

13. A method as set forth in claim 1, in which the surface treatment is an anisotropic dry etching, said method comprising the steps of:

bringing a gas which is well reactive with said substrate into contact with a surface of a substrate to compound a gas including a component element of the substrate by a chemical reaction between the material of the substrate and the gas thereby removing the material of the substrate from the surface of the substrate, and

irradiating the surface of the substrate with a fast particle collimated beam to enhance an activity of the surface and/or the gas thereby increasing a rate of the removal of the material of the substrate in a direction along which the collimated beam is directed towards the surface of the substrate.

14. A method as set forth in claim 13, in which said irradiation step is carried out with the particle beam having particle energy in the range of 200 eV - 1 keV.

15. A method of etching a surface of a substrate, comprising the steps of:

bringing a gas which is well reactive with the substrate into contact with a surface of a substrate to compound a gas including a component element of the substrate by a chemical reaction between the material of the substrate and the gas thereby removing the material of the substrate from the surface of the substrate, and;

irradiating the surface of the substrate with an ultraviolet light beam or a laser beam to enhance an activity of the surface and/or the gas thereby increasing a rate of the removal of the material of the substrate in a direction along which the collimated beam is directed

towards the surface of the substrate.

16. An apparatus for applying a surface treatment to a surface of a substrate, the surface treatment being selected from a group consisting of the following surface treatments: coating, denaturation, modification and etching, said apparatus comprising:

a reactor housing in which the surface treatment is conducted;

a source for supplying a gas into said reactor housing; and

a fast particle beam device for generating a fast particle beam and irradiating the surface of the substrate with the beam so as to enhance an activity of the surface and/or the gas thereby facilitating reaction between the surface and the gas.

17. An apparatus as set forth in claim 16, in which said fast particle beam device supplies a beam selected from a group consisting of an electron beam, a charged particle beam, an atomic beam and a molecular beam.

18. An apparatus as set forth in claim 17, in which said apparatus further comprises a reactor housing, and a turntable provided in the reactor housing and having an axis about which the turntable is rotated and a surface normal to the axis for receiving a flat substrate thereon, and said fast particle beam device directs the beam towards the surface of the substrate at an angle relative to the surface.

19. An apparatus for generating a fast particle beam comprising:

a housing for receiving a predetermined gas,

anode and cathode plates provided in said housing with a predetermined spacing being interposed therebetween and arranged in parallel with each other, anode and cathode plates each being provided with a plurality of through holes, said spacing being set to be in the range of D/14 - D, in which D is a diameter of the anode and cathode plates,

the anode and cathode plates being adapted to be applied with a high voltage to cause a plasma discharge

therebetween to ionize the gas thereby forming a fast particle beam.

20. An apparatus as set forth in claim 19, in which said range is 1 mm - 14 mm.